Projecting the epidemiologic and economic consequences of a quadrivalent HPV vaccine in the United States

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Outline

- Model overview
- Model validation
- Some results
- Summary of findings

Model overview

- Direct and indirect ‘herd immunity’ effects of vaccination
  - Describe transmission of the virus and resulting disease in a population
  - Assess impact of vaccine on vaccinees and their contacts
- An integrated disease transmission model and cost-utility analysis
  - Demographic model
  - Behavioral model
  - HPV infection and disease models
- US healthcare system data
  - Assumes existing screening practices

Vaccination strategies

Description	Definition
I. Routine 12-year-old females	Vaccinate females before reaching age 12
II. 12-year-old females + 12–14-year-old females catch-up	Strategy I + a temporary catch-up program targeting 12–14-year-old females
III. 12-year-old females + 12–17-year-old females catch-up	Strategy I + a temporary catch-up program targeting 12–17-year-old females
IV. 12-year-old females + 12–19-year-old females catch-up	Strategy I + a temporary catch-up program targeting 12–19-year-old females
V. 12-year-old females + 12–24-year-old females catch-up	Strategy I + a temporary catch-up program targeting 12–24-year-old females

Vaccine characteristics: data and assumptions

- Vaccine take (% of vaccinees with vaccine effect)
  - HPV 16/18 100%, HPV 6/11 100%
- Vaccine degree of protection
  - HPV 16/18, HPV 6/11: against infection 90% (CI:74–100)
  - HPV 16/18, HPV 6/11: against disease 100% (CI:87–100)
- Vaccine duration of protection
  - HPV 16/18, HPV 6/11: 10 years to lifetime
- Breakthrough infections
  - Infectiousness and clearance same as natural infections

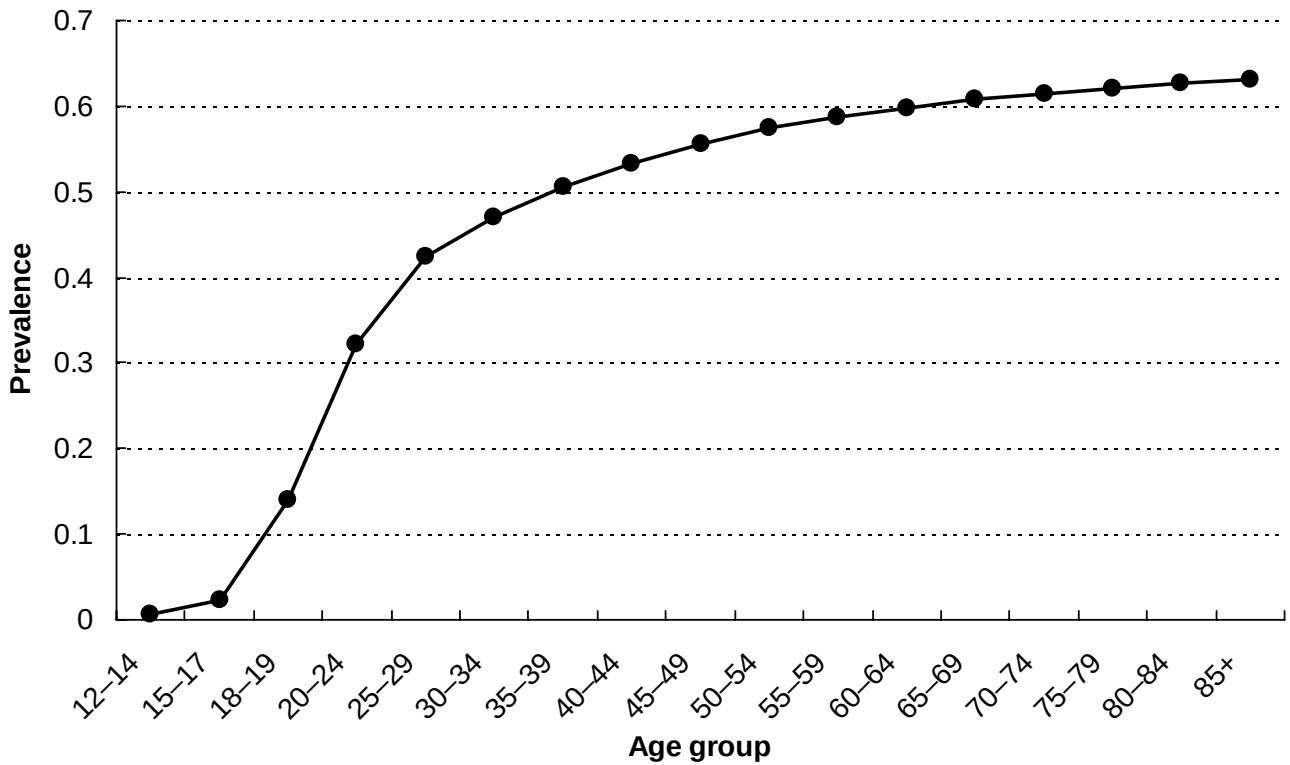
Vaccination penetration rates: assumptions

- Routine 12-year olds
  - increase vaccine penetration linearly from 0% in Year 0 to 70% in Year 5 and after
- Catch-up program
  - Include only those who were never vaccinated before
  - Increase vaccine penetration linearly from 0% in Year 0 to 50% in Year 5
  - Program stops after 5 years

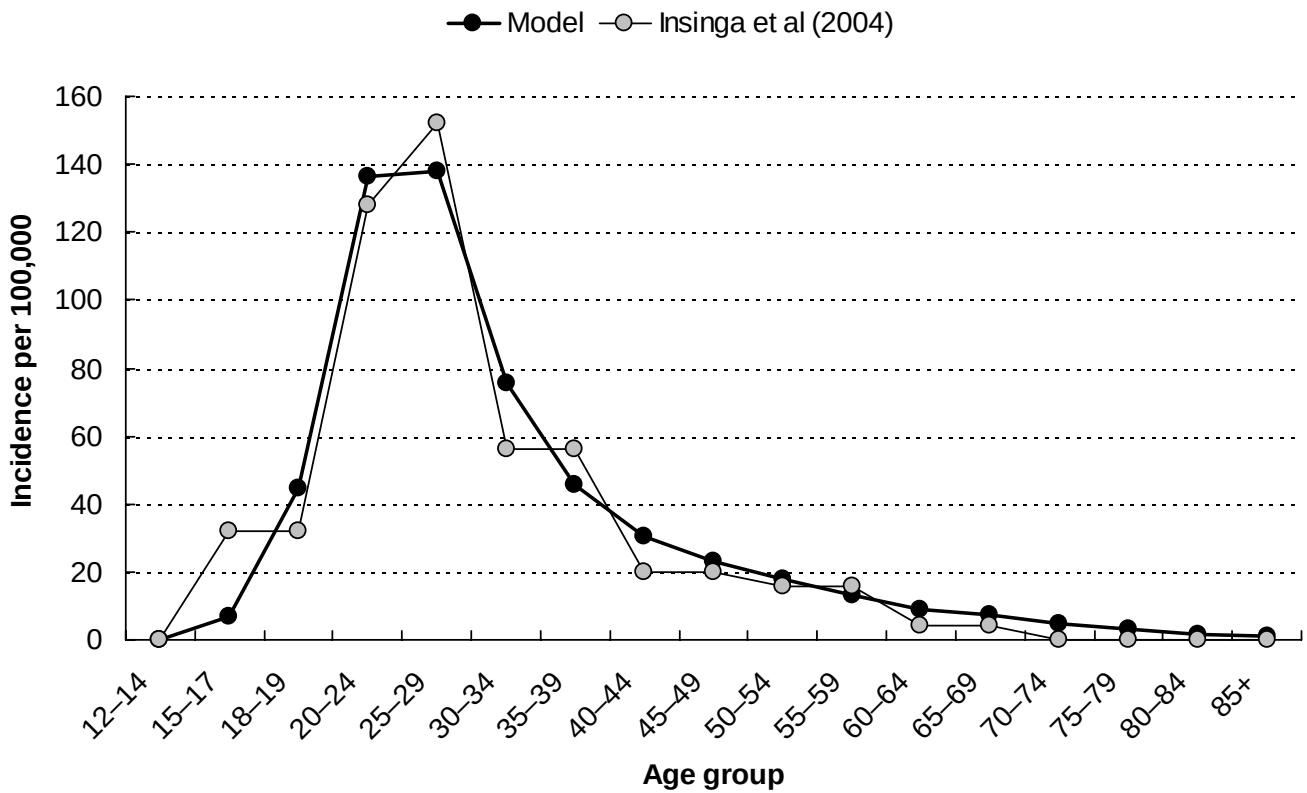
Model validation

- Model assumptions: reasonable?
- Process for building model
- Model equations and inputs are available for review
- Model is programmed in Mathematica®
- A series of tests to debug and establish technical accuracy
- Predictive validity: predictions within range of found in the literature
  - HPV prevalence
  - genital warts
  - CIN 1, 2, 3
  - cervical cancer incidence
  - cervical cancer death

Steady-State proportion of females currently or previously infected with HPV 16/18 by age, no vaccine

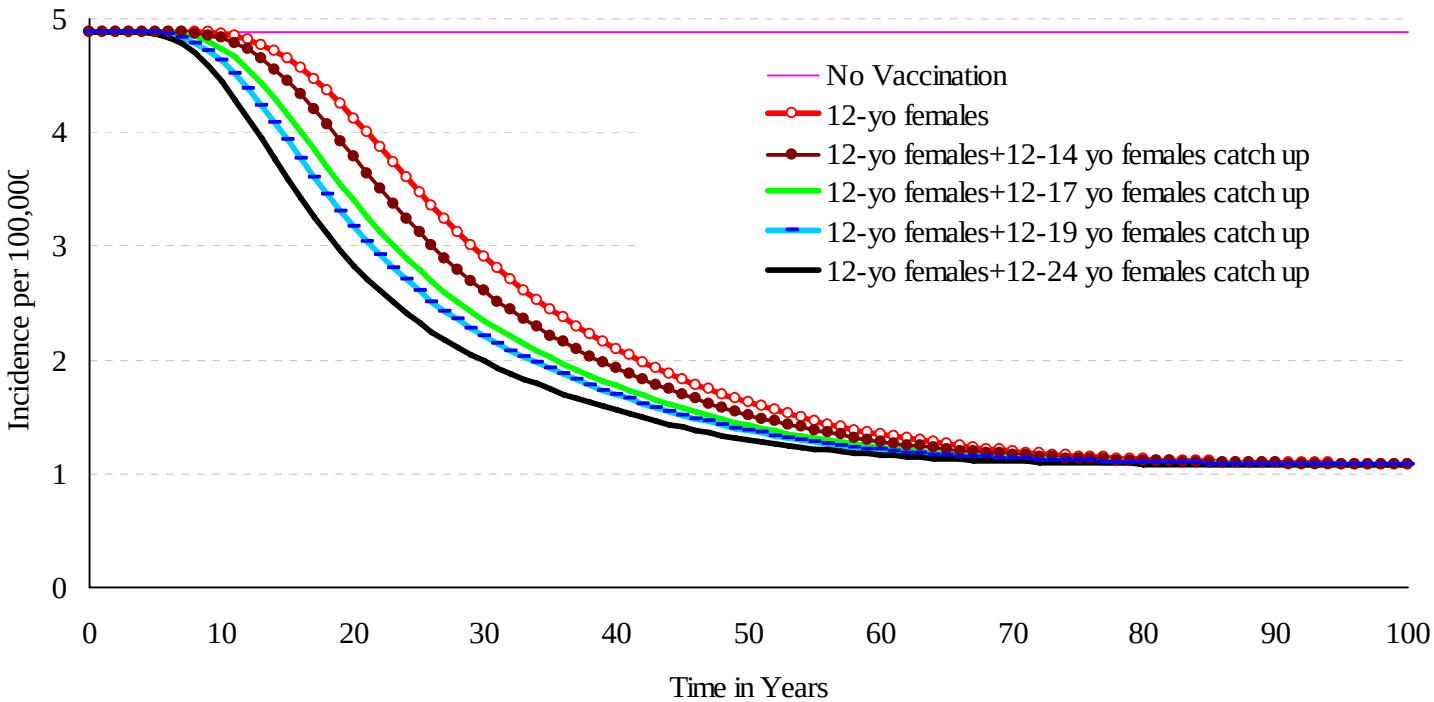


Steady-State HPV 6/11/16/18-related CIN 2 incidence by age, no vaccine

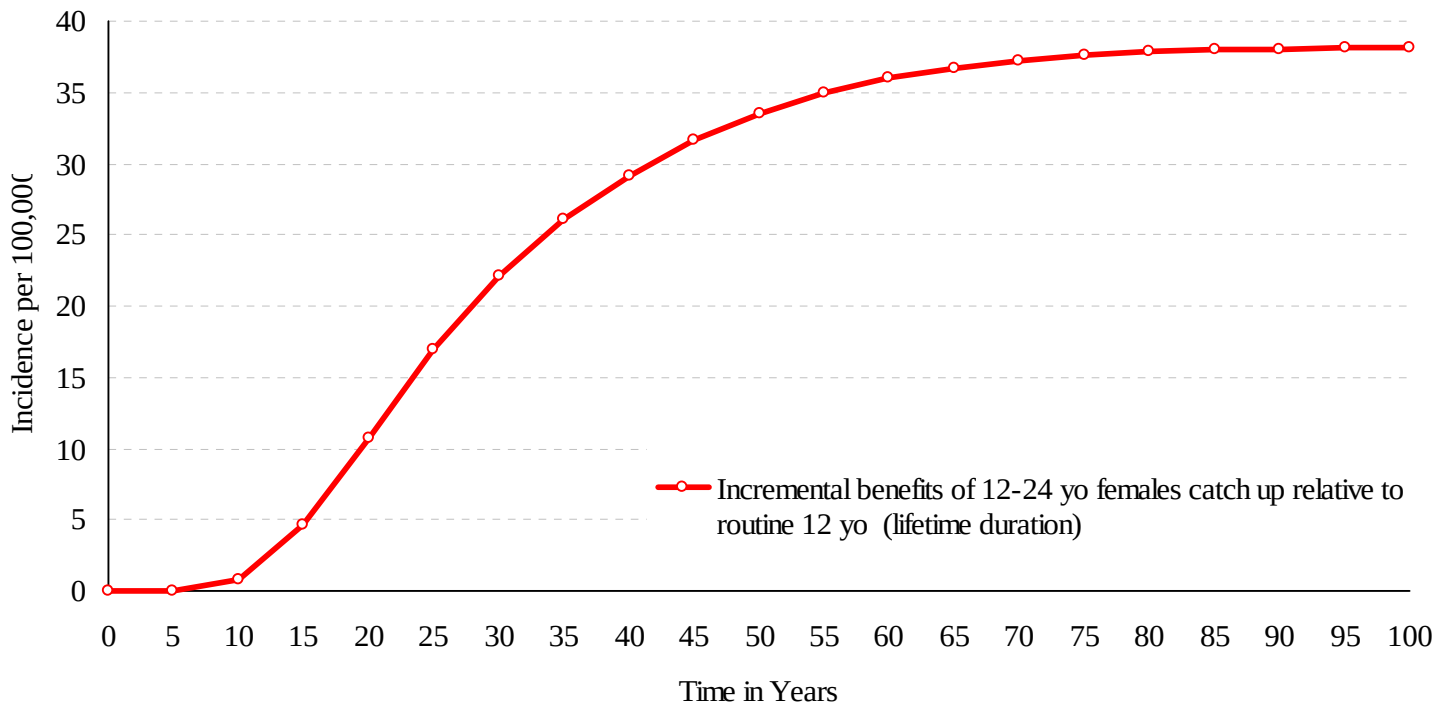


Assumes 40% of CIN 2 in Insinga et al (2004) are due to HPV 6/11/16/18

Impact of vaccination strategies HPV 16/18-related cervical cancer incidence (age12+y) lifelong duration



Cumulative incremental impact of vaccination strategies, HPV 16/18-related cervical cancer (age 12+y)



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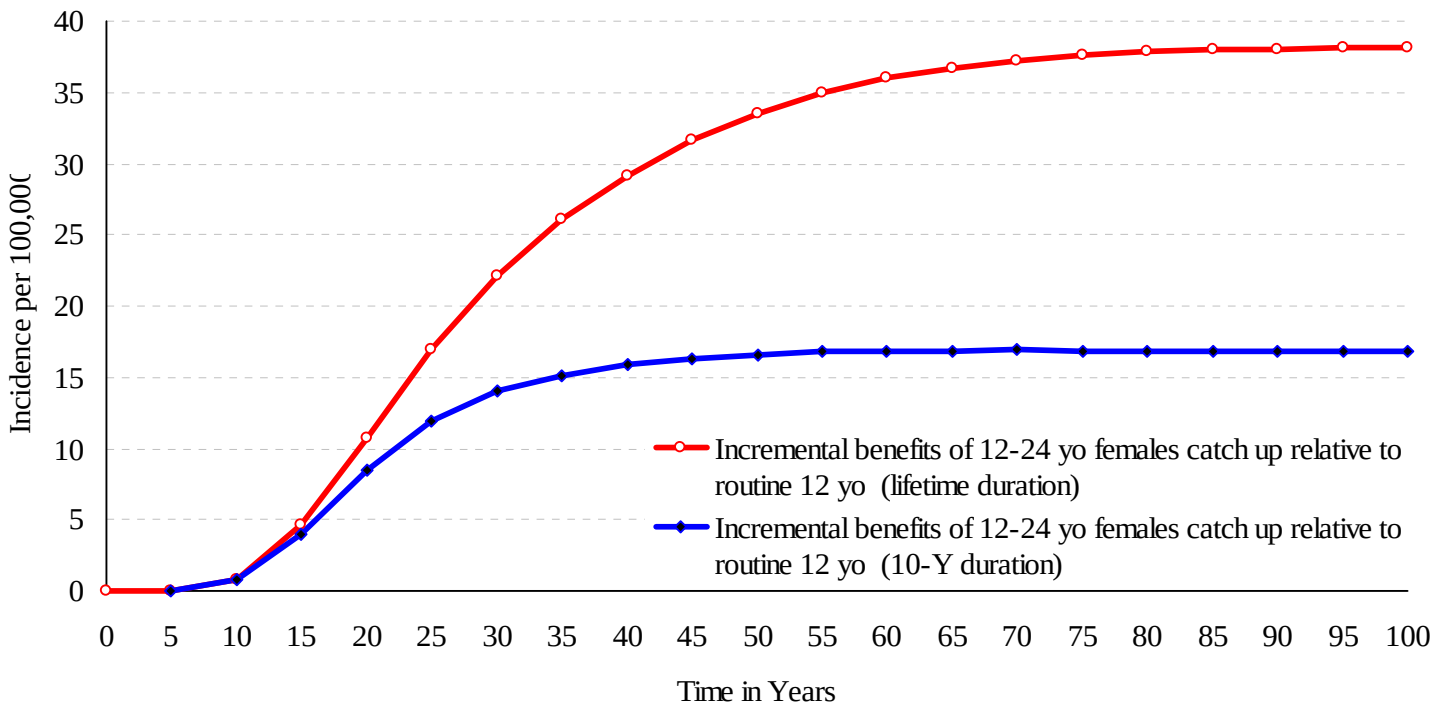
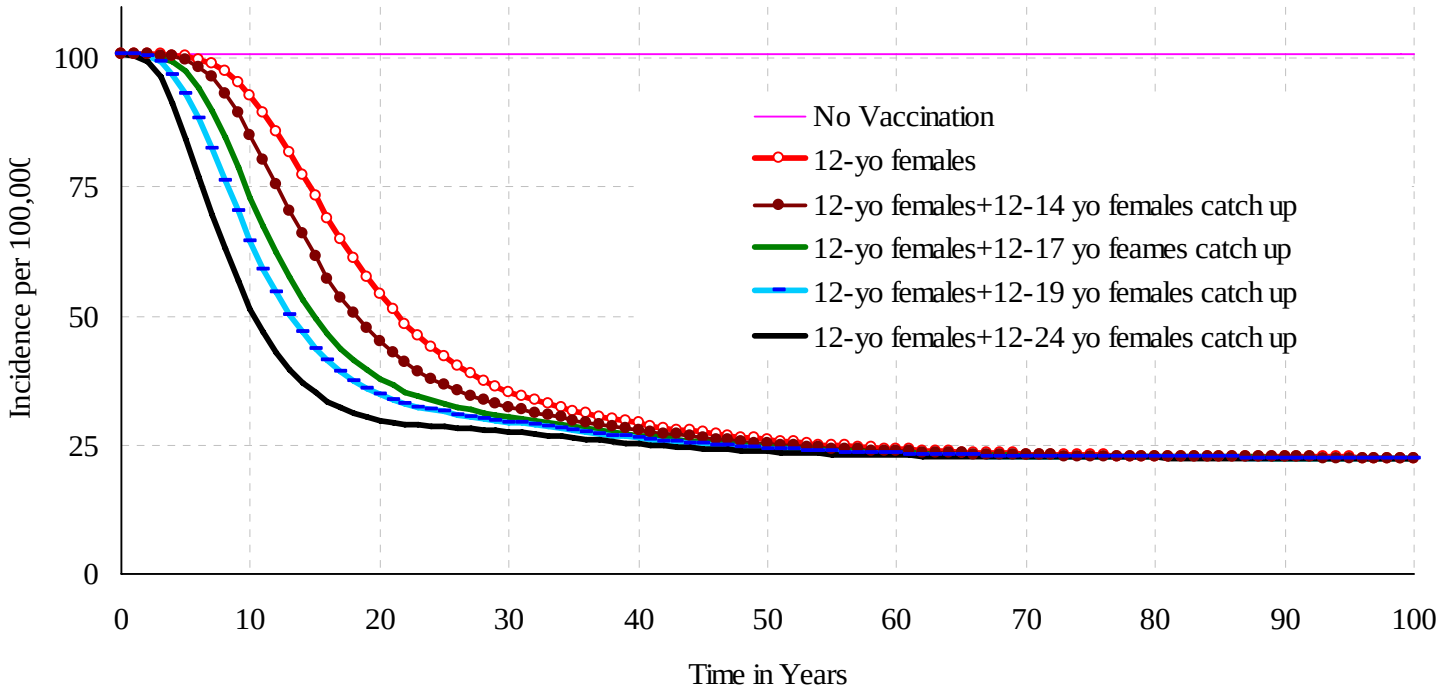


Additional HPV 16/18-related cervical cancer cases prevented in the U.S. in the next 25 years

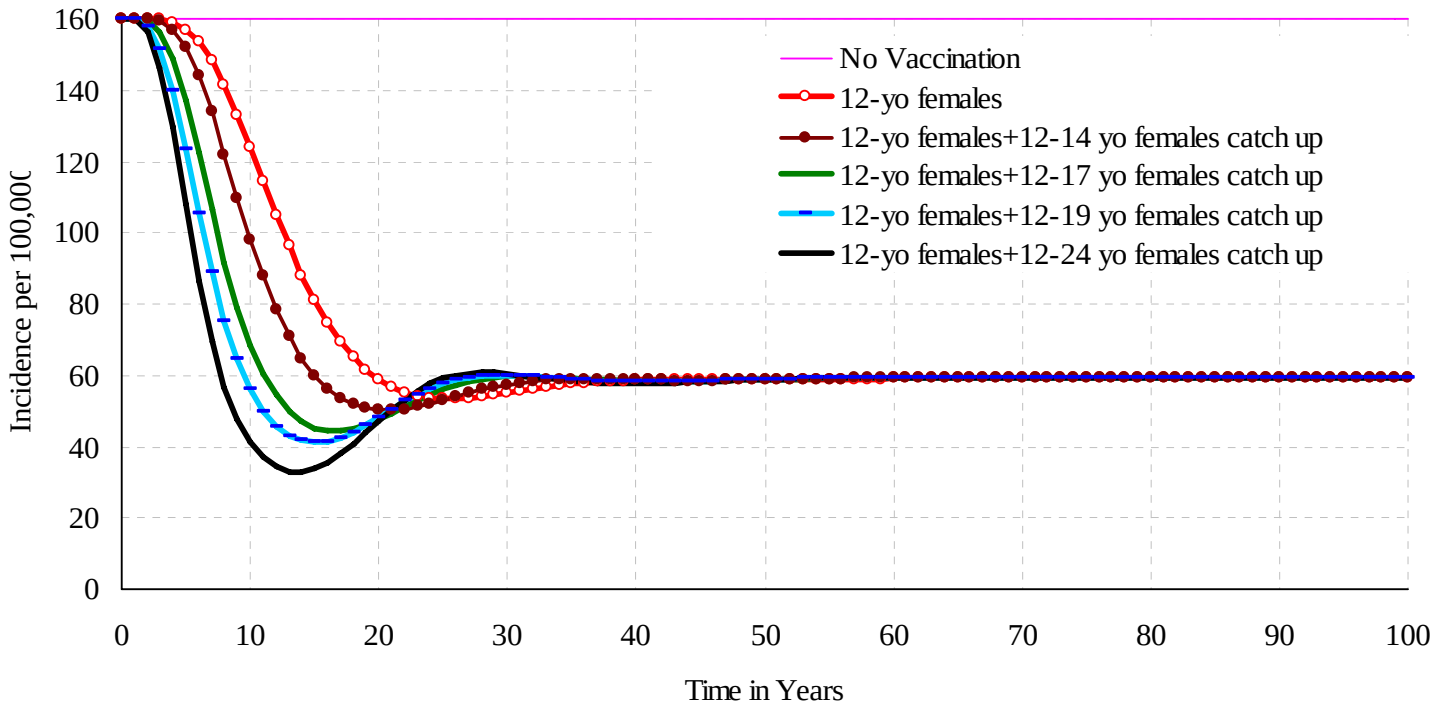
Strategy	Cervical Cancer*
Routine 12-year olds	10,124
+12–17-year	10,181
+18–19 -year	3,980
+20–24 -year	6,134

*Assumes lifetime duration

Impact of vaccination strategies HPV 6/11/16/18-related CIN 2/3 incidence (age12+y) lifelong duration



Impact of vaccination strategies HPV 6/11-related genital warts incidence males (12+y)

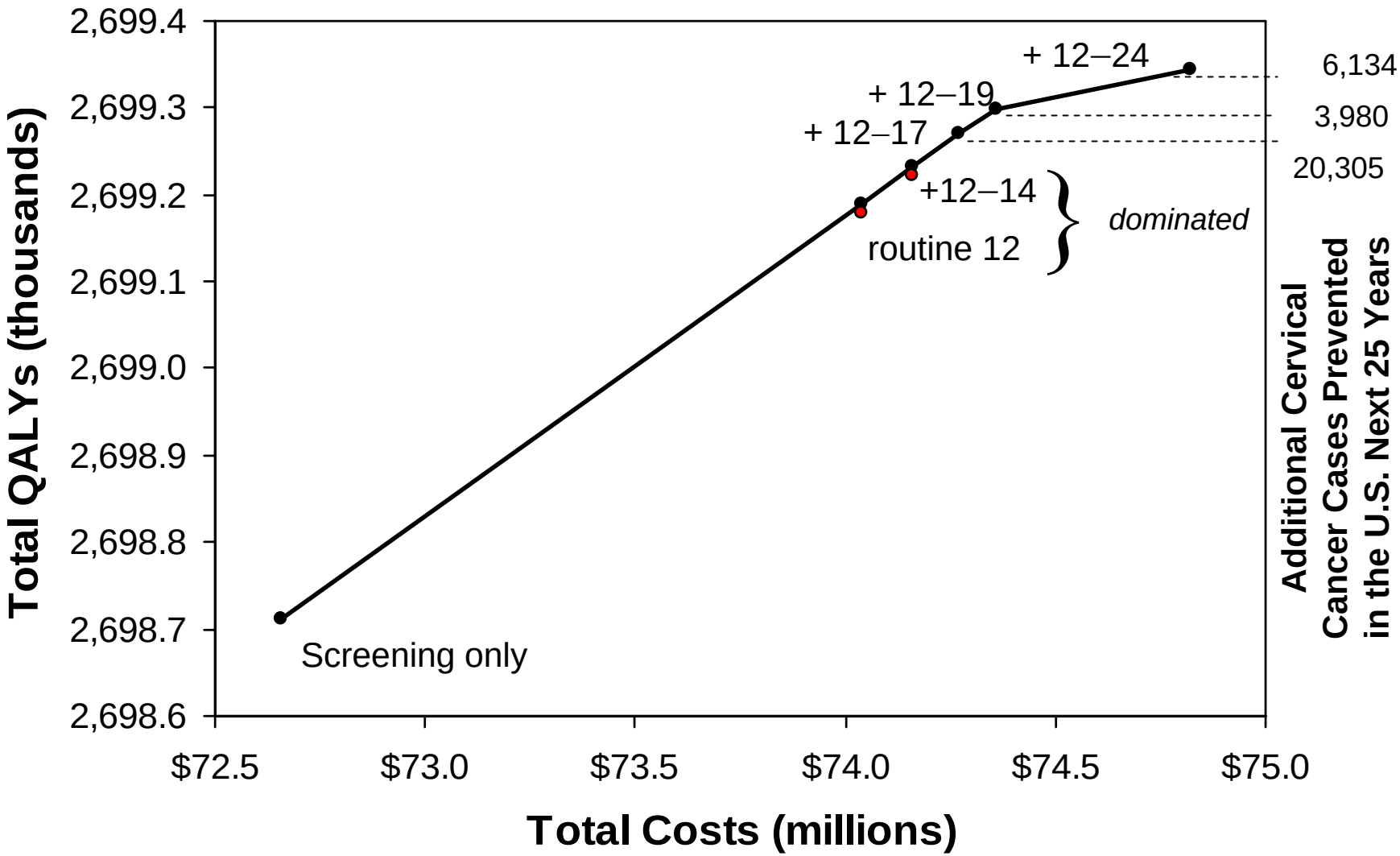


Cost-effectiveness analysis of HPV vaccination strategies*

Strategy	Discounted total		Incremental		
	Costs	QALYs	Costs	QALYs	$/QALYs**
No vaccination	72,659,302	2,698,711	—	—	—
12-years females	74,042,990	2,699,178	1,383,687	467	Weakly dominated
+ females 12-14 years catch up	74,162,330	2,699,222	119,340	45	Weakly dominated
+ females 12-17 years catch up	74,266,869	2,699,270	104,539	48	2,874
+ females 12-19 years catch up	74,358,223	2,699,299	91,354	29	3,150
+ females 12-24 years catch up	74,815,667	2,699,343	457,444	44	10,362

*Assumes cost of vaccination series is $360 and duration of protection is lifelong.
**Compared with the preceding non-dominated strategy.

Efficiency curve for comparing alternative vaccination strategies



Summary

- A prophylactic quadrivalent HPV vaccine can:
  - be efficiently added to current screening programs
  - reduce the incidence of cervical cancer, CIN, and genital warts
- Catch up vaccination can provide earlier and greater reductions in HPV-related disease
- Vaccinating females before age 12 combined with a temporary 12–24-year olds catch up program can be cost-effective

Limitations & outstanding research questions

- Vaccine characteristics (e.g., duration of protection and degree of protection), preference weights, and cost of vaccination are influential
- Need more and better epidemiologic and natural history of disease data to support model
- Need to add other important HPV-related diseases such as vulvar and vaginal neoplasias and cancers, recurrent respiratory papillomatosis
- Need to model HPV types interaction/cross protection
- Need to reflect the indirect costs of HPV-related disease
- As screening guidelines change the model will alter to reflect the shifting impact of vaccination